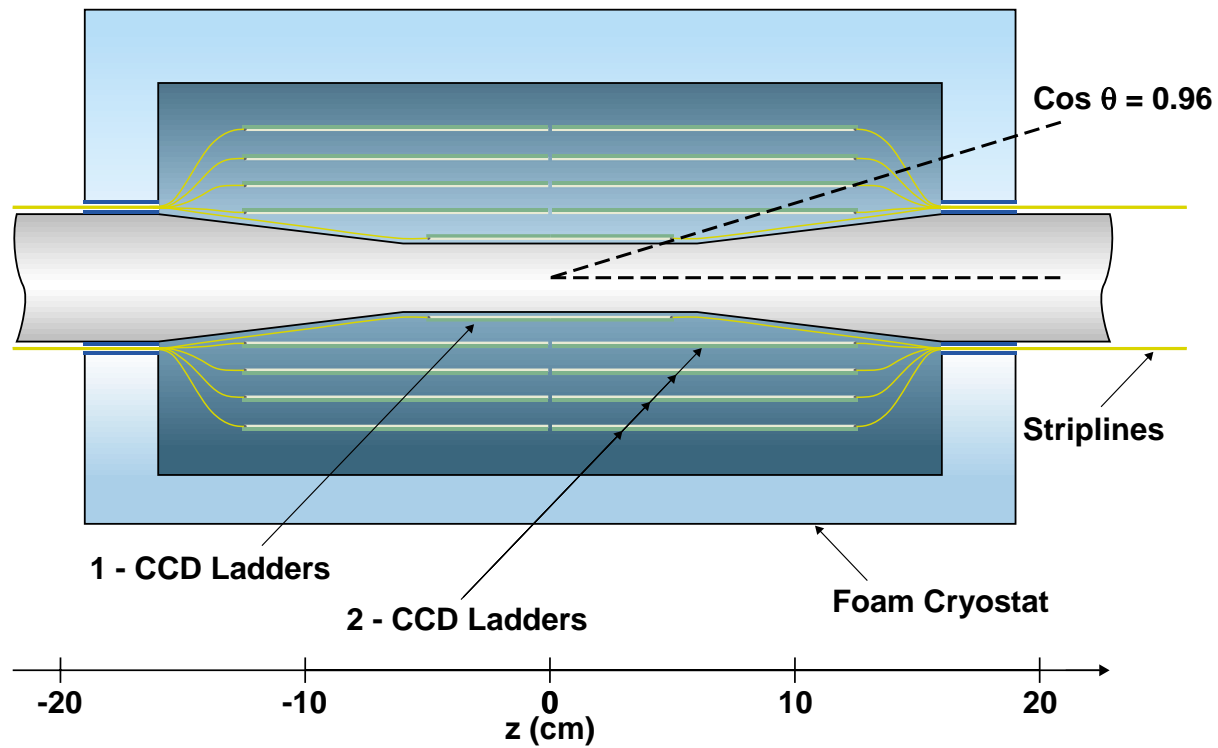


New CCDs

Brookhaven National Lab
Chris Damerell
November 2001

- Novel CCD developments for a host of application areas
 - reduced clock voltages for consumer market: video and still photography
 - LLLCCD for surveillance, star trackers etc
 - high throughput devices for future X-ray telescopes
- Ongoing cross-fertilization between such developments and CCDs for particle tracking
- Focus on the CCDs for a vertex detector at the future TeV-scale e^+e^- linear collider

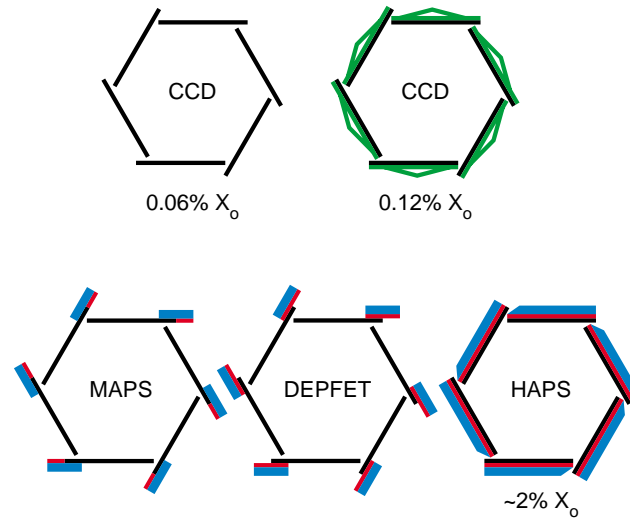
- Now almost unanimous agreement on optimal detector layout:



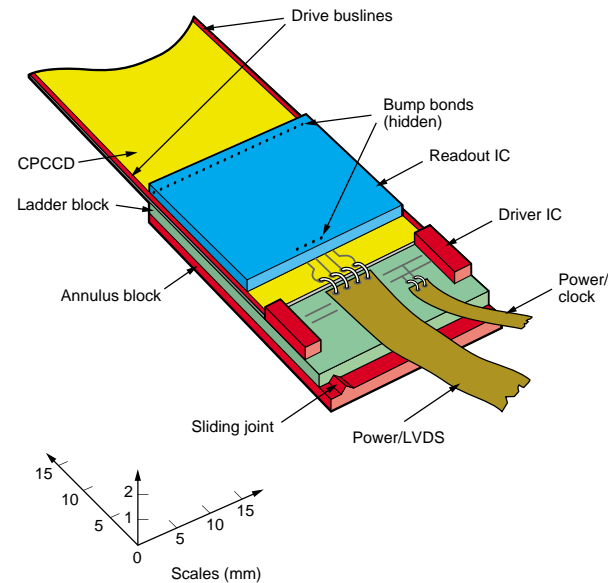
- Pixel-based (microstrips faded out in 1993)
- Concentric long barrels ('lampshade' variant still considered up to time of TESLA TDR.
Would make sense in context of a thick-layer fallback option)
- Measure space points with precision $< 5\mu\text{m}$ in each layer
- Layer thickness $\lesssim 0.1\% X_0$
- Layer 1 readout time $\lesssim 50\mu\text{s}$ required for TESLA
8 ms OK for NLC/JLC
(this became clear in November 1998)
- Modest radiation hardness
- While the goals are clear, the means to get there are not
- Very dynamic: 4 technologies being pursued (CCD, MAPS, DEPFET and HAPS)

- If more than one technology achieves the above goals, decision will probably become clear on basis of **material budget**
 - This matters all the way to $|\cos \theta| = 0.996$ (LAT outer edge at 83 mrad)
[similar considerations relevant to TPC/silicon tracker comparison]
 - γ conversions and secondary interactions are dangerous for energy flow quality of forward jets
 - Mechanical supports need to provide $\sim 1 \mu\text{m}$ stability
 - Inner electronics material budget by no means quantified
 - Cables and optic fibres probably modest for all options
 - Cooling requirements could be decisive
- **Need full sized, fully functional prototype ladder before taking *any* technology seriously**
[the devil is in the details]
- **Meanwhile, important for all concerned to avoid overselling any option**

- $r - \phi$ views



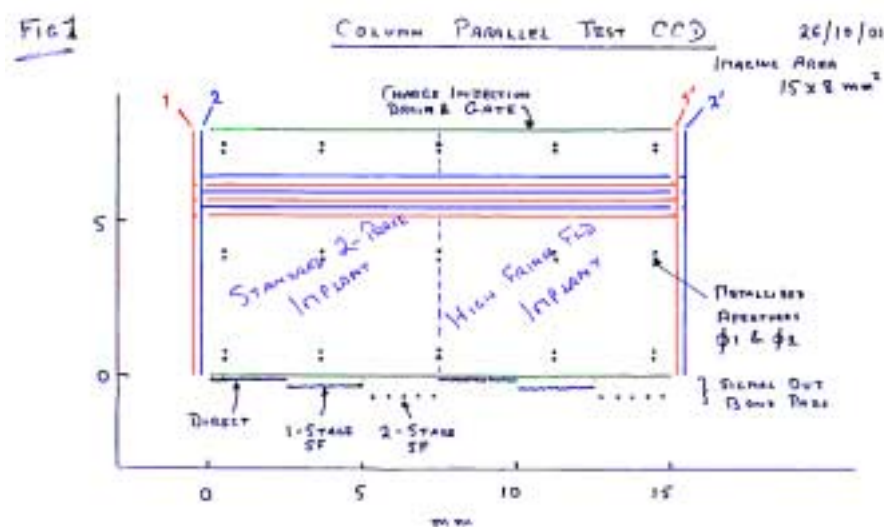
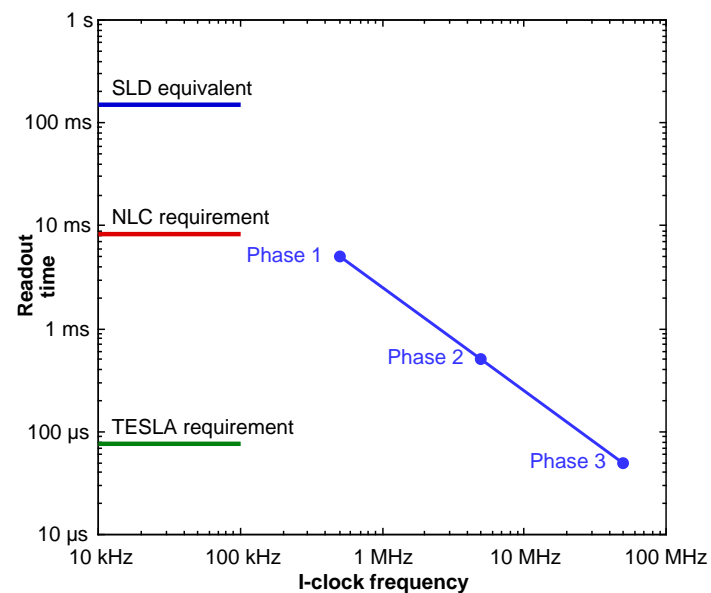
- Material requirements beyond active ladder ends are relatively unknown for all options



- R&D for thin ladders (applicable to CCD, MAPS and DEPFET) currently only in LCFI collab

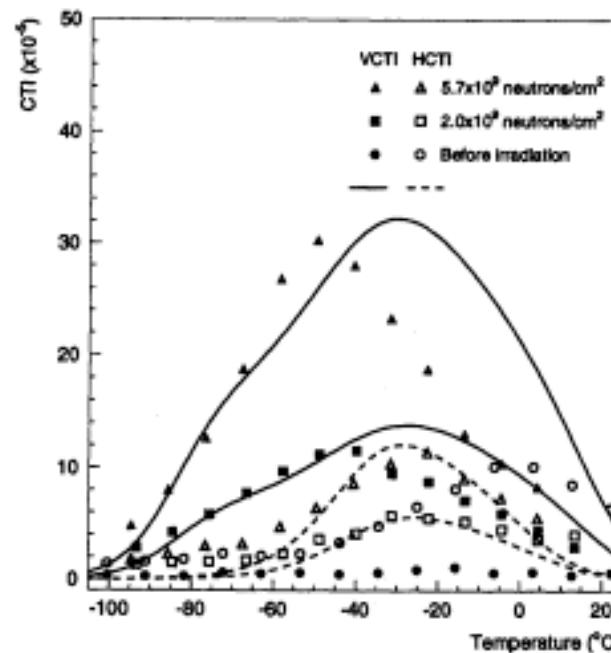
CCD R&D Status

- Proposal to PPESP of March 2001 was cautiously staged



- Has recently metamorphosed into a multi-faceted set of test CCDs which will explore all three phases in parallel
- Experience at MTech with XMM and other recent CCD designs is proving invaluable
- 'Dream team' of David Burt et al, Marcus French, Steve Thomas, Konstantin Stefanov, Tony Gillman...

- Column parallel ideally suited to real-time pipelined data sparsification
- Reduced clock voltages the key to acceptable power dissipation. Hope to retain massless gas cooling
- Test devices should be available by Summer 2002
- Radiation hardness – good news for CCDs



- Each technology has its list of possible show-stoppers. One for the CPCCD (recently solved) was the busline inductances. **More dangerous are the ones we don't know about!**